APPENDIX VA

IMPLEMENTATION PLAN

for the

TEXAS DEPARTMENT OF TRANSPORTATION

AUSTIN DISTRICT

FREEWAY TRAFFIC MANAGEMENT SYSTEM

Transportation Operations
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INTRODUCTION

This implementation plan is intended to describe how traffic management systems will be implemented by the Texas Department of Transportation (TxDOT) Austin District. The information provided in this plan is intended to illustrate that traffic management systems are designed, built, operated, and maintained in the most efficient manner possible, considering performance, cost, and schedule.

This implementation plan is an evolving document. Revisions and updates are anticipated at regular intervals as deemed necessary by the TxDOT Austin District Transportation Operations. Priorities and initiatives for the TxDOT Austin District reflect local public concern. As public concern changes, so will this implementation plan.

LEGISLATION

We are all governed by laws passed by legislative bodies. At the Federal and State level congressional bodies debate and pass laws regulating a variety of activities relating to traffic management systems. Generally, these laws are codified, or systematically grouped, in specific areas. These codes define the law. Often the code does not prescribe how the law is executed. Agencies must develop administrative procedures for executing the requirements of the law.

These procedures are often codified as administrative code. Codified laws and procedures generally do not get codified in more than one code. Therefore, it is sometimes necessary to review several codes when investigating a subject.

This plan can not possibly review and assess each and every legislative action which may affect a freeway traffic management system. The plan described in this document requires no additional legislation at this time to implement. However, any law at any level of government involving transportation or communications will have an effect on this plan. This section is intended to demonstrate a cognizance of legislation, policy, procedure, and where information can be found so it can be monitored for change.

Federal

Federal legislation influences the Austin District implementation plan. Many projects providing equipment and materials involve Federal assistance. Federal assistance is facilitated through the passage of Congressional bills. Currently, assistance in the area of transportation is provided by the Transportation Equity Act for the 21st Century (TEA-21) of 1998.

This Act authorizes funds to be made available to the States through particular categories of work on the transportation system. Generally, these categories provide assistance for preliminary engineering, design, and construction. Historically, categories dedicated for operation and maintenance have been limited. Generally, states must finance the maintenance and operation of the system once it is constructed. As more complex and technologically advanced traffic management systems are constructed, the need for maintenance and operational assistance can be expected to grow.

TEA-21 continues the enhanced role of the local metropolitan planning organization (MPO) on project planning and development enacted in previous legislation. The Austin Transportation Study (ATS) is the MFO providing guidance in the Austin area. ATS may develop criteria required to develop traffic management projects in addition to State and Federal codes. Generally, the Federal Highway Administration (FHWA) administers federal highway funds while the Federal Transit Administration (FTA) administers federal transit funds contained in the Act.

Procedures for utilizing federal assistance are documented in the Code of Federal Regulations (CFR). For example, this implementation plan has been prepared in accordance with Title 23, Part 655.409 of the Code of Federal Regulations (23 CFR 655.409).

State

Legislation at the State level also affects this implementation plan. The General Appropriations Act (HB1) contains directives regarding procedures for and limitations on state agency spending.

HB1 identifies strategies in the areas of design, construction, maintenance, and operations. These strategies are largely funded through a legislated state motor fuel tax. Revenues from this tax are dedicated to highway purposes. Revenue made available through federal assistance closely follows the motor fuel tax.

Regulatory laws may be found in Vernon's Texas Civil Statues (VTCS). These civil statutes define the law. Most statutes relating to traffic management systems have been codified in the Transportation Code.

Two laws, codified in the Transportation Code (TRC), directly relate to traffic management. TRC 472.012 authorizes TxDOT to remove personal property from the right of way or roadway if it determines that the property blocks the roadway or endangers the public safety. TRC 550.022 (b) states that the operator of a vehicle involved in an accident on certain portions of a freeway shall move the vehicle as soon as possible under certain conditions to minimize interference with freeway traffic. This law has often been referred to as the "Move It" law in Texas.

Procedures described in the General Appropriations Act, other legislative bills, and officia1 agencypolicy are incorporated into the Texas Administrative Code (TAC). The TAC describes how an agency will fulfill the obligation of laws. Title 43, Part I of the TAC (43 TAC Part I) involves TxDOT. The TAC describes specific policies and procedures dealing with local ITS steering committees, multiple use of highway right of way, freeway corridor management systems, and removal and storage of spilled cargo and personal property. For instance 43 TAC 25.7 describes how TxDOT complies with TRC 472.012

TxDOT Policy and Procedure

The Transportation Code establishes a three member Texas Transportation Commission. The members are appointed by the Governor. An executive director is selected by this commission as the administrative head of TxDOT. Together, the Texas Transportation Commission and the Executive Director of TxDOT, have broad authority to establish policy and procedure in the design, construction, maintenance, and operation of highways in Texas.

TxDOT Executive Order l-89 explains the various types of policy and procedure affecting TxDOT. This executive order explains the existence of rules, commission policy, administrative policy, operating procedures, and technical procedures.

Other Legislation

As traffic management systems become morecomplex, there may be a need to investigate legislation by other governmental bodies. At this time, other country, county, or city legislation is not known to significantly impact this plan.

SYSTEM DESIGN

The initial traffic management system design involves only freeway traffic management. In the future, additional systems could and should be a part of the overall system. The Austin area early deployment plan indicated favorable early benefits from incident management. Therefore, the initial system design is primarily concerned with freeway incident management. This design is influenced by many factors.

System Designer

TxDOT has been aggressively developing signal and freeway traffic management systems with in-house expertise since the early 1970's. TxDOT Division personnel have long been able to support local District staff with useful advice.

Austin District staff has been learning as other TxDOT Districts have been implementing freeway traffic management systems. This in-house expertise has been fostered and increased through technology sharing meetings with other TxDOT Districts as advanced freeway traffic management systems have begun operation in Texas.

As the freeway traffic management system evolves and is integrated with other components of an intelligent transportation system (ITS) infrastructure, consultants may be necessary to perform complex integrations. Successful design, construction, maintenance, and operations can be achieved in the near term with in-house Austin District and TxDOT Division personnel.

System Design Life

Many urban areas in the United States have systems that are still in operation 20 years after initially constructed. However, given today's technological advances, these systems are felt to be sorely out of date. For this reason, a maximum design life of 10 years appears reasonable without consideration of any upgrades. Ideally, equipment should be considered for staggered replacement every five years.

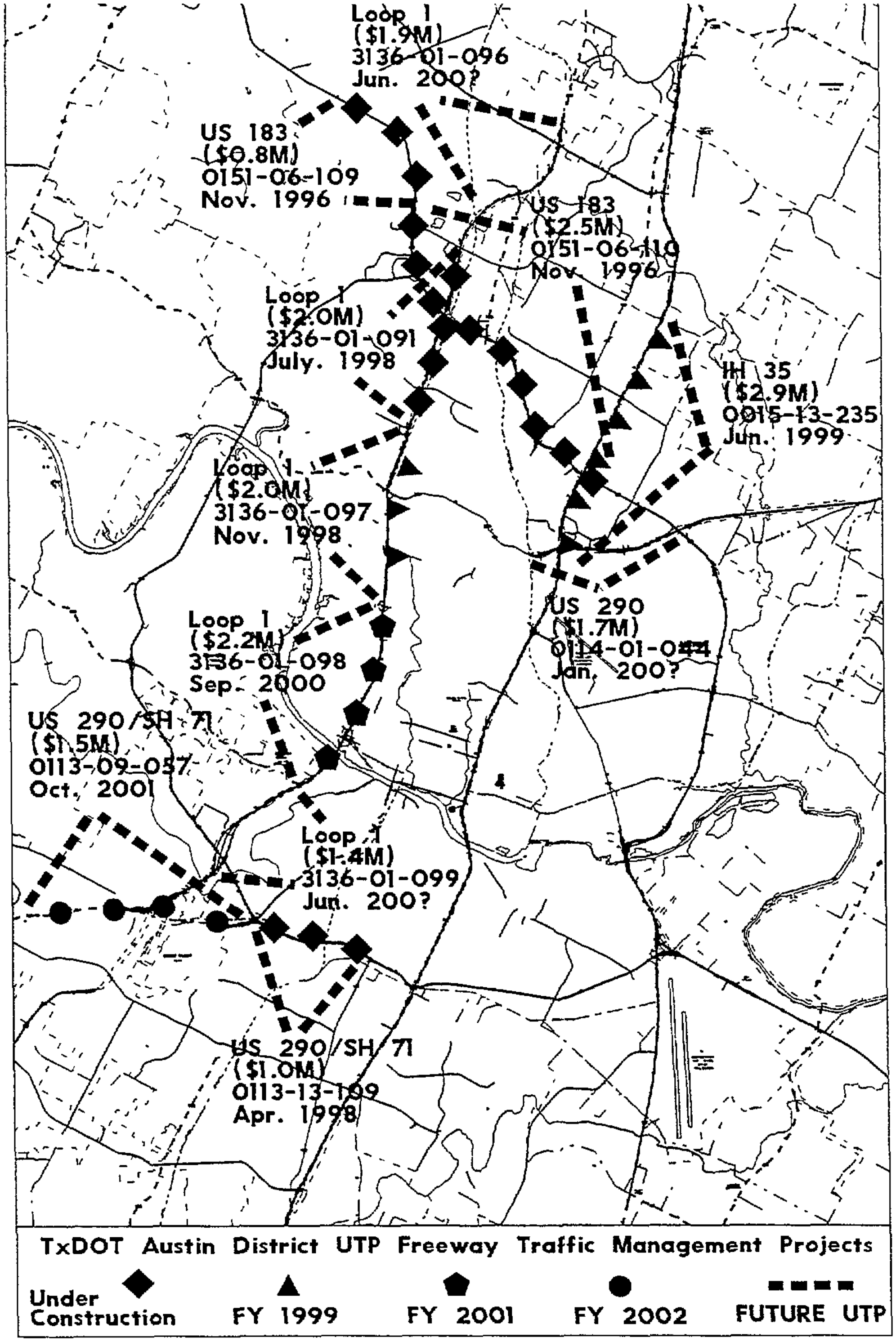

Figure VA-1_Austin Area FTM Projects

System Coverage

The Austin District has envisioned a freeway traffic management system to cover all expressways within the District boundary. Currently, existing expressways include IH 35, US 183, US 290, and LP 1 (Figure VA-1). These roadways are almost exclusively contained in the metropolitan planning organization (MPO), Austin Transportation Study (ATS), boundary. The ATS boundary encompasses the three counties of Williamson, Travis, and Hays. However, most of the expressway FTM corridors are contained only in Travis County (Table VA-1).

An important corridor, IH 35, bisects the ATS boundary. This corridor passes through San Antonio to the south, through Hays, Travis, and Williamson Counties to Dallas-Ft. Worth to the north. It is envisioned that freeway traffic management systems will be needed along this corridor as it passes through these heavily traveled counties.

System Design Operations/Maintenance Philosophies

Many advanced traffic management systems have struggled with operations and maintenance. Indeed, data indicates that while these advanced systems can cost millions to design and construct, maintenance and operations can cost much more over the life of the system.

Sy	Hwy	Project Limits	C	S	J	County	Letting FY Yr	Mon	Mile Mkr Beg	+ Disp_B	End Mile End	+ Disp_E	Proj cl Lnth	mile cl C&D	XSt ea SCS	mile cl FTM	Estimated Cost Construction	Estimated Cost Maintenance	Add FTE	E S SCU	T LCU	I CMS	M LCS	A CCTV	T Loop	E Ramp
IH	35	Subtotal for NHS Category 3D _ FTM Related				246								27 500	0	27 500	$20,625,000 00	$836,000 00		3 8500	3	110	28	110	69	1513
IH	35	Subtotal for NHS Category 3D _ FTM Related				227								27 954	0	27 954	$20,965,500 00	$849,801 60		3 9136	3	112	28	112	70	1537
IH	35	Subtotal for NHS Category 3D _ FTM Related				106								24 348	0	24 348	$18,261,000 00	$740,179 20		3 4087	2	97	24	97	61	1339
US	183	Subtotal for NHS Category 3D _ FTM Related				246								17 732	0	17 732	$13,299,000 00	$539,052 80		2 4825	2	71	18	71	44	975
US	183	Subtotal for NHS Category 3D _ FTM Related				227								26 829	0	26 829	$20,121,750 00	$815,601 60		3 7561	3	107	27	107	67	1476
US	290E	Subtotal for NHS Category 3D _ FTM Related				227								11 265	0	11 265	$8,448,750 00	$342,456 00		1 5771	1	45	11	45	28	620
US	290	Subtotal for NHS Category 3D _ FTM Related				227								15 073	0	13 653	$10,594,750 00	$415,051 20		1 9540	1	55	14	55	34	751
SH	71	Subtotal for NHS Category 3D _ FTM Related				227								15 080	0	16 500	$12,020,000 00	$501,600 00		2 2674	2	66	17	66	41	908
LP	1	Subtotal for NHS Category 3D _ FTM Related				246								1 300	0	1 300	$975,000 00	$39,520 00		0 1820	0	5	1	5	3	72
LP	1	Subtotal for NHS Category 3D _ FTM Related				227								25 542	0	25 542	$19,156,500 00	$776,476 80		3 5759	3	102	26	102	64	1405
SH	45	Subtotal for NHS Category 3D _ SCS Related				246								8 586	0	8 586	$6,439,500 00	$261,014 40		1 2020	1	34	9	34	21	472
SH	45	Subtotal for NHS Category 3D _ SCS Related				227								33 533	0	33 533	$25,149,750 00	$1,019,403 20		4 6946	3	134	34	134	84	1844
SH	130	Subtotal for NHS Category 3D _ SCS Related				246								16 000	0	16 000	$12,000,000 00	$486,400 00		2 2400	2	64	16	64	40	880
SH	130	Subtotal for NHS Category 3D _ SCS Related				227								18 500	0	19 000	$14,125,000 00	$577,600 00		2 6450	2	76	19	76	48	1045
		Subtotal for NHS Category 3D _ FTM Related				Var								192 623	0	192 623	$144,467,250 00	$5,855,739 20		26 9672	19	770	193	770	482	10594
		Subtotal for NHS Category 3D _ SCS Related				Var								76 619	0	77 119	$57,714,250 00	$2,344,417 60		10 7817	8	308	77	308	193	4242
		Subtotal for Central Control Center	914	0	100	227	2001	10					0 001	0 000	0	0 000	$8,000,000 00	$640,000.00		0 0000	0	0	0	0	0	0
		Total for NHS Category 3D Related												269 242	0	269 742	$210,181,500 00	$8,840,156 80		37 7489	27	1079	270	1079	674	14836

Table VA-1_Summary of Expressway FTM Corridor Projects

The driving force in the design of traffic management systems for the Austin District is to maximize needed traffic management efforts while minimizing the maintenance and operations cost. Some design decisions are made so as to reduce the personnel and equipment required for operations and maintenance. This philosophy may sometimes result in a higher one time cost for equipment and training, however, these are weighed against long term benefits.

The *Texas Highway Operations Manual* provides additional detailed information on system design and management considerations.This manual is maintained by the TxDOT Traffic Operations Division.

Incident management is historically a large portion of operations in a management center. Collecting data for planning purposes will also be a large focus of the system design.

Incidents are often typified by high lane occupancy (density), andlow speeds. The impacts of these characteristics are multiplied as traffic volume increases. These are the parameters that the system will use to initially manage traffic. Volumes are also an important component in roadway planning. The ability to store this data provides the Department with a valuable planning tool.

The freeway traffic management system design initially concentrates on incident management. When an incident is reported to the operator, cameras would be used to verify and manage the response. Operators would coordinate the response with other agencies as needed, determine the necessary traffic control plan, and inform motorists if necessary. Initial components in the system include surveillance (detectors and cameras), communication (voice, data, and video), and control (signs, signals, gates, and radio). All of these components are controlled from a central site. Eventually, a combined communication and management center with other agencies is desirable in order to integrate the freeway traffic management system with regional public safety computer aided dispatch (CAD), traffic signal, and transit systems.

A conceptual incident scenario begins with the detection of an incident. An operator could be notified of a roadway incident from voice calls or from vehicle detectors which measure volume, occupancy, and speed. Typical detector data indicating an incident may be high detector occupancy coupled with low speed. Previous high volume data would lead an operator to assume a large problem was developing, Unfortunately, this data is very similar to congestion which does not represent an incident.

A historical database of detector data could be used to help determine if the detector data represents congestion or an actual roadway incident. This database would need to include lane and time of day information.

Incidents must be verified. Again, this could be accomplished by voice calls from observers at the scene. Closed circuit television (CCTV), however, provides another means of visually verifying a roadway incident remotely.

Once an incident has been detected and verified it should be managed. The freeway can be managed by informing motorists of the incident and possible action to be taken. Dynamic message signs (DMS), lane control signals (LCS), and highway advisory radio (HAR) are a proven effective means of informing motorists of roadway conditions. DMS can provide simple localized information and inform a motorist to tune to HAR for more detailed information. LCS can guide motorists to the appropriate lanes. HAR can provide more complex localized or area wide information.

It is important to note that this system is operational 24 hours a day. Human monitoring, however, will begin only on a part time basis during peak travel conditions as needed. As the system expands, so will the times of human monitoring.

Existing facilities at the TxDOT Austin District headquarters will be used to accommodate human monitoring. An interim control center has been established at the Austin District Traffic Signal Shop. It is envisioned that this facility can adequately support part-time human monitoring until the freeway traffic management system approaches 30 centerline miles. At this time, a larger facility specifically designed for advanced traffic management system management will be necessary.

Austin District staff are currently working with local county and city transportation, public safety, and emergency agencies on the possibility of operating from a centralized center. It is envisioned that a centralized facility could be constructed as the interim control center ends its useful life.

TxDOT Traffic Operations Division, Traffic Management, with the assistance of the Austin and El Paso Districts developed an *Operations Concept Document.* The document provides additional detail on how a standard Advanced Traffic Management System (ATMS) will be used in a Traffic Management Center (TMC) to support traffic and emergency operations.

System Architecture

Freeway traffic management systems designed by in-house TxDOT personnel function as an open standards, distributed processing systems. A distributed system offers the most flexibility for control of the system.The size of a central control facility can be reduced by implementing a distributed processing design. In a distributed processing system design, many devices needed to organize raw data can be located outside the central control facility. Simply moving raw data all the way to a central control site can be infrastructure intensive. In addition, if the central site fails, the system fails. A distributed processing system design can accommodate a central control center failure without allowing the entire system to fail. If any site acting as central control fails, another site can be easily and quickly configured as the central control.

TxDOT Traffic Operations Division, Traffic Management Section developed a document titled *Freeway Traffic Management System, Roadway to IVHS.* This document provides a technical discussion of the system architecture.Additional discussion of system architecture can be found in the document *Core Technology Architecture* maintained by the TxDOT Information Systems Division.

This distributed system architecture will take advantage of existing and emerging standards as they are developed. The system will also support the National ITS Architecture under the guidance of the FHWA.

System Integration

An open standards, distributed architecture will maximize the opportunity for integration with other systems inside and outside TxDOT. A freeway traffic management system should be designed to coordinate and communicate information to and from other systems for increased efficiency.

An enormous potential exists to integrate data within TxDOT, especially in the Austin District. Maintenance and construction activities affect freeway travel in the Austin District. Integrated freeway traffic management can support and provide additional information not currently available to the public, enabling these activities to take place more efficiently and safely.

Currently, Division, District, County, and City planning offices deploy technology to gather information on the transportation system. These technologies can be integrated into traffic management systems to provide seamless data collection for all offices. This could also lead to lower equipment maintenance costs.

A regional effort exists to rehabilitate and integrate several public safety and service systems in the Austin area. This effort is referred to as 9-1-1 RDMT (Figure VA-2). 9-1-1 RDMT includes regional initiatives in 9-1-1, trunked radio (R), computer aided dispatch (D), mobile data terminals (M), and intelligent transportation systems (T).

A centralized 9-1-1 RDMT operations facility shared with transportation, public safety, and emergency service agencies will be more successful if systems and data integration take place. All of these agencies are concerned with the condition of the transportation network. Centralized or not, integrated information is necessary to efficiently manage agency resources.

9-1-1 RDMT Participating Entities

- **City of Austin**
  - ***Police***
  - ***Fire***
  - ***EMS***
  - ***Office of Emergency Management***
  - ***Public Works – Traffic Signals***
- **Travis County**
  - ***Sheriff's Office***
  - ***Constable's Office***
  - ***Emergency Services***
  - ***Office of Emergency Management***
  - ***17 Emergency Services Districts/ & Volunteer FDs***
- **TxDOT**
  - ***Freeway Traffic Management***
  - ***I.T.S***
- **Capital METRO**
  - ***Operations***

Figure VA-2_9-1-1 RDMT Entities

Project	Funding	Source
9-1-1	**$3.37m**	**CAPCO**
_R_adio	**$39.025M**	**Participating Entities** **COA Bond Authority**
CA_D_/_M_DT	**$8.3m**	**COA** **Participating Entities**
_T_ransportation Mgt.	**$16.096m**	**TxDOT** **COA**
GIS	**$3.2m**	**CAPCO** **COA** **Travis County**
Microwave	**($3m)**	**PCS Vendors**
Combined Center	**$8.9m**	**Participating Entities**

Figure VA-3_9-1-1 RDMT Funding

The TxDOT Austin District has funded a portion of some 9-1-1 RDMT initiatives (Figure VA-3). This includes a request for offer to integrate the City of Austin CAD system, as well as, other regional systems with the Advanced Traffic Management System (ATMS) being designed under the direction of the TxDOT Traffic Operations Division. ATMS will be used to manage the freeway traffic management system in the Austin District. TxDOT is also involved in funding a combined emergency communication and transportation management center with some of the 9-1-1 RDMT entities.

System Components and Functions

System components and functions can be divided into three groups. These groups are surveillance, communication, and control (SC&C). Hardware components for distributed processing of these functions can also be divided into three areas. These areas are field, communication, and management levels of the system.

Surveillance

Surveillance is the primary means of detecting incidents. Monitoring roadway conditions is only one way of detecting incidents. Monitoring 911 telephone calls and emergency services dispatching is also an effective means of detecting incidents.

Surveillance also includes monitoring and evaluating the system through reporting and analysis. Daily status, incident, alarm, and user ad hoc reports provide operators and managers with necessary information to effectively manage system components and functions.

Surveillance primarily involves detection. Vehicles are normally the subject of this detection. However, ice detection of the travel surface is also being considered for implementation in the Austin District.

Detectors

Generally, inductive loops are used in freeway traffic management systems due to their reliability and cost effectiveness. Other detector technologies such as video, sonic, infrared, and radar detectors may be used in the future. Ideally, corridor wide data is needed to effectively provide integrated management along the freeway. Detectors are, therefore, placed on all lanes including freeway, frontage road, ramps, and connectors.

Freeway detectors are located at areas of anticipated congestion. One example of this is the merge area of an entrance ramp. Freeway detectors are also needed at areas of anticipated free flow, such as long tangent sections with a significant separation between ramps.

Some detector data about the conditions of the frontage road are needed. Vehicles may need to be diverted from the freeway to the frontage road to avoid an incident. Likewise, detector data may be needed to divert frontage road traffic to the freeway.

Speed is generally not a consideration on exit ramps. However, speed may be significant data on an entrance ramp or connection. Additionally, entrance ramps may be metered in the future. It would be ideal to integrate these initial loops into the future ramp metering system. Currently, fixed metering rates are believed to be the most effective. Speed may be a significant item for responsive gap based metering, if that technology improves in the future.

CCTV

Surveillance also involves verification and visual monitoring. Closed circuit television (CCTV) is used to accomplish this function.

Verification is needed along the freeway, as well as, frontage roads. Ideally, visual images along intersecting arterials shouldalso be provided. Therefore, cameras are placed at intersections with arterial streets and visual gaps along the freeway are filled in with additional cameras. It is also desirable to overlap and stagger the placement of the cameras to provide comprehensive freeway and frontage road coverage.

Communication

Communications includes the transmission of voice, data, and video. Voice communications will be needed to minimize the number of maintenance and operations personnel. Data transmissions are how most of the surveillance information is relayed and controlled. Video transmission is needed for the CCTV system.

Voice

Voice communication is primarily provided to support maintenance personnel. Voice communications are provided at all roadway device enclosures. Many times it is necessary for maintenance personnel to speak with an operator at the control center to test various remote functions.

Data

Field hardware includes camera control units, dynamic message sign (DMS) controllers, AM transmitters, and local control units (LCUs). All but the LCU are proprietary units that currently do not share other functions. The LCU has been developed by the TxDOT Traffic Operations Division, Traffic Management Section and includes many functions. The LCU collects and distributes data for specific field devices. These devices include detectors, lane control signals (LCS), ramp meters, ramp gates, and dynamic signs. One LCU can accommodate 12 detector pairs, 24 single detectors, 6 lane control signals, 2 ramp meters, 2 ramp gates, and 4 dynamic signs.

Communications hardware includes dial-up and limited distance modems (LDMs), add/drop multiplexors (ADMs), and fiber optic transceivers. LDMs are used to distribute information to individual field devices. This information is multiplexed over fiber optic cable to the management level.

The management level hardware includes system control units (SCUs) and managerial workstations running software on a local area network. SCUs collect and process information from up to 64 LCUs over eight RS-232 channels. Workstations are used to control field equipment and manage information processed by the SCU.

Video

An important component of communications is the transmission of video images. Many agencies, as well as the public, are interested in images illustrating roadway conditions. Video images also provide critical information needed by emergency response agencies. These images help to ensure that the right resources are dispatched at the right time to the right place.

Control

Initial control functions include the use of closed circuit television (CCTV), dynamic message signs (DMSs), lane control signals (LCSs), travelerinformation station/highway advisory radio (TIS/HAR), ramp gates, and other roadside devices. All of these functions are necessary in the freeway traffic management system. DMSs are used to communicate short, simple pieces of information to motorists. LCSs are used to communicate the condition of travel lanes in the immediate vicinity. HAR is used to communicate longer, more complex information to the motorist.

Ramp meter signals, gates, and dynamic signs are used in conjunction to directly control the flow of vehicles entering the freeway. These devices will be utilized, as needed in the future, to enhance the initial control components.

These control functions are used to manage incidents. Many of these control functions could be automated through the use of simple software and hardware rules. In the future, an expert system could be developed to provide greater uniformity and assistance to the operator.

DMS

A dynamic message sign is a large sign in which messages can be changed dynamically. Normally large characters are used in accordance with the Texas Manual on Uniform Traffic Control Devices (TMUTCD).

Dynamic message signs (DMSs) are typically located to the side of the travel lanes in advance of driver decision points. These decision points may be major interchanges or detour points for incident management.

Generally, these signs can only convey short and simple information to the driver. Typically, these signs consist of 3 or 4 lines of text, 14 to 15 characters long.

LCS

A lane control signal (LCS) is a signal head mounted over a travel lane. Different messages are displayed on the LCS head to inform drivers of the condition of the lane ahead. The messages used by the LCS are defined in the Texas Manual on Uniform Traffic Control Devices (TMUTCD):

TIS/HAR

Traveler Information Station/Highway Advisory Radio is used to broadcast more detailed information to the driver. During an incident, TIS/HAR may be used to broadcastdetour information. At other times, scheduled road closings and maintenance activities can be broadcast to the driver.

Communication Subsystem Design and Approach

The communication subsystem is a hybrid of a fewwell known standards. The interface for all data terminal equipment (DTE) and data communication equipment (DCE) is the Electronics Industries Association (EIA) Recommended Standard 232 (RS 232). All hardware whether at the field, communication, or management level conform to this standard.

Communication among field devices takes place over twisted wire pairs typically operating at speeds of 9,600 bits per second (9.6 kbps) or greater. Communications for these field devices are grouped or hubbed together at convenient locations, typically at highway overpasses.

Hub enclosures house the necessary communications equipment thatare being hubbed. The hub enclosure is designed to accommodate LCUs and related hardware. An additional 19” equipment rack is sometimes provided for other necessary and future communications or control equipment. The enclosure may also accommodate environmental control equipment if necessary.

It is not cost effective to operate and maintain each field device on a twisted wire pair communication circuit to a control center. Therefore, communications at the hub are multiplexed. Multiplexing is way of applying technology to permit a communication circuit to carry more than one signal.

Deciding on what multiplexing technology to use is currently a question of economics and functionality. A digital signal level of 1 (DS 1) or T1 (1.544 Mb/s) is a cost effective multiplex rate. T1 data rates and supporting equipment are reliable and widely available. Therefore, field data is typically multiplexed at a T1 rate to the control center.

Fiber optic transmission medium has been chosen because of reduced maintenance and operations cost. Optical fibers are not susceptible to electrical and environmental interference that plagues copper conductors. Fiber optics should be more cost effective to maintain because of its lower failure rate and longer life when compared to copper.

Another benefit of fiber optics involves video. An analog video signal requires a large bandwidth for transmission. Copper conductors can not efficiently transmit such a large bandwidth signal for significant distances required along roadway corridors. However, fiber optical cable can transmit a large bandwidth signal over long distances efficiently.

When video signals are transmitted in analog form over fiber optics, each camera normally utilizes a dedicated optical wavelength to transmit its signal over a single fiber. As the system grows, it is more efficient to multiplex several video signals on a single fiber. This can be accomplished by utilizing different optical wavelengths for each video signal on a single fiber.

Another economy of scale may be realized if the video signal is digitized as well. As previously discussed, data is already multiplexed in the field. This data is digital. If analog video signals are digitized they may be able to use the same equipment and technology as the data signals. A digital signal level of 3 (DS3) or T3 (44.736 Mb/s) currently represents an acceptable rate to transmit digital video signals. Multiplexing digital video signals at T1 and T3 over fiber optic cables is quite easily done over an optical carrier level 1 signal (OC-1) in a synchronous optical network (SONET). The electrical building block for SONET is equal to OC-1 and is called a synchronous transport signal level 1 (STS-1). The rate of an OC-l/STS-1 is 51.840 Mb/s.

There is another compelling reason to utilize the T1 and T3 rates described above. The State of Texas General Services Commission(GSC) provides telecommunication services for many State agencies. GSC owns fibers in a fiber optic network in the Austin area called the Greater Austin Area Telecommunications Network (GAATN). GSC operates their fibers on the network at SONET optical carrier levels 3, 12 and 48 signals (OC-3, OC-12, and OC-48). The City of Austin also owns fibers on the GAATN and utilizes SONET carrier levels. There is an opportunity to use this network for redundancy.

The management level of the freeway traffic management system operates on an Ethernet local area network (LAN). Workstations can easily be locally or remotely linked using existing reliable SONET technology (Figure VA-4).

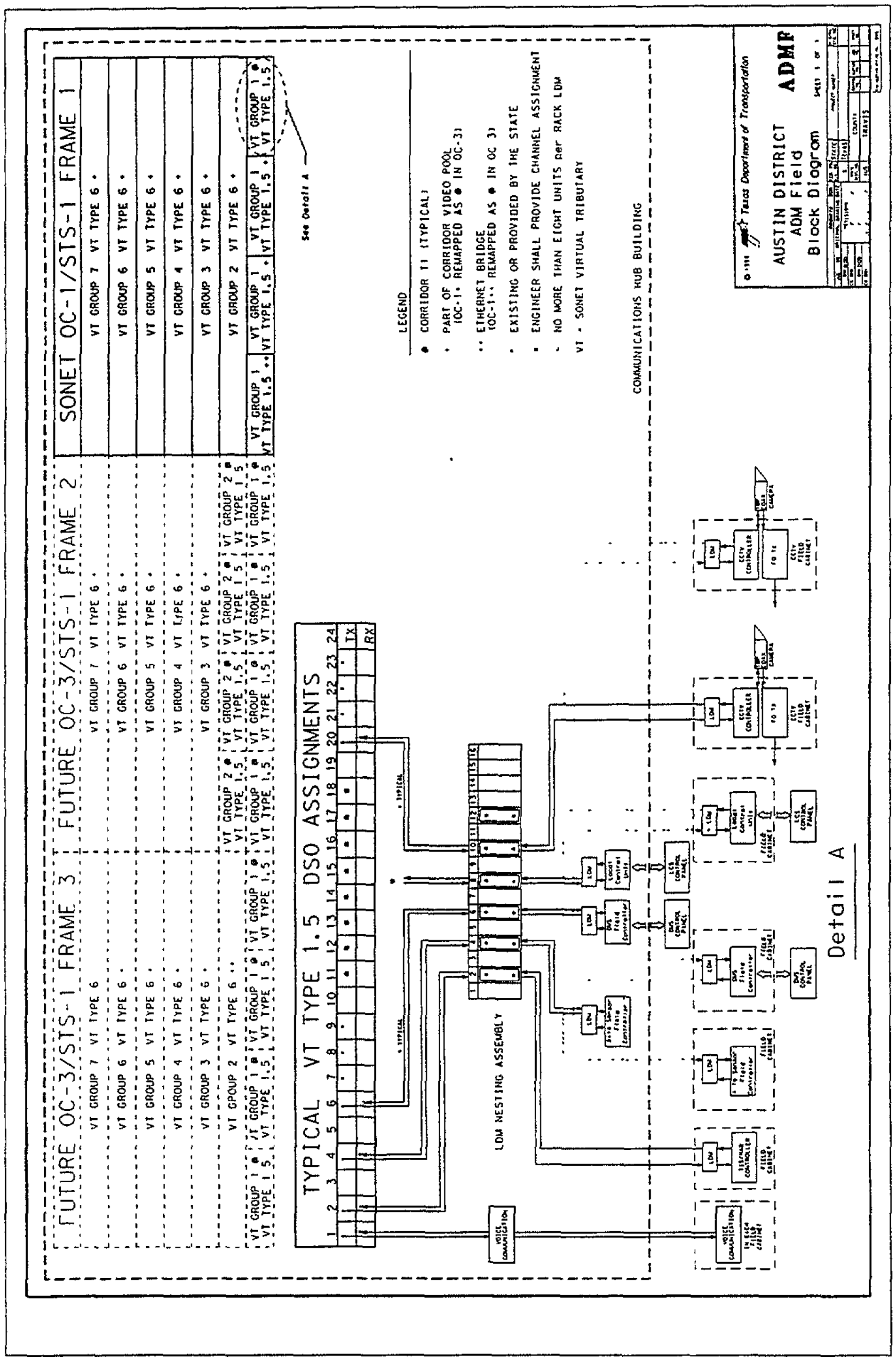

Figure VA-4_Austin District SONET

Traffic Operations Center Design Features

An existing building at the Austin District Headquarters is used as an interim control center. The location of this interim facility is strictly governed by convenience. A larger control center will be needed as the system expands.

An interim control center has been established at the Austin District Traffic Signal Shop. It is envisioned that this facility can adequately support part-time human monitoring until the freeway traffic management system approaches 30 centerline miles. At this time a larger facility specifically designed for freeway traffic management will be necessary.

The interim control center has amenities such as a restroom, sink, refrigerator, and microwave to support part-time staffing. Showers are located in a building nearby, but only accessible during regular business hours.

The interim control center is also located in close proximity toexisting TxDOT maintenance and operation facilities. The freeway courtesy patrol is also headquartered in the District Signal Shop. Nearby is the area maintenance section responsible for the expressways in the initial system deployment. The District headquarters is also where public information is disseminated for the Austin District.

The interim center has raised floors and a video monitoring wall. Two workstations can be accommodated to manage traffic.

Austin District staff are currently working with local county and city transportation, public safety, and emergency service agencies on the possibility of operating from a centralized center. It is envisioned that a centralized facility could be constructed as the interim control center ends its useful life after about five years. Currently, TxDOT along with other 9-1-1 RDMT partners have funded a consultant study to provide and conceptual design of a centralized center.

Project Phasing/Scheduling

Initial system coverage will concentrate on Austin expressways recently converted from conventional divided highways. These facilities offer cost effective opportunities to implement freeway traffic management. Much of the conduit and detection (C&D) infrastructure can be placed during roadway construction (Table VA-2 and Figure VA-5). Projects will be phased in order to construct a complete system loop around Austin (Figure VA-1). Projects associated with the 9-1-1 RDMT initiatives are phased in relation to schedules that can be accommodated by the participating agencies. The schedule for each initiative is somewhat independent of one another (Figure VA-6).

Sy	Hwy	Project Limits	C	S	J	County	Letting FY Yr	Mon	Mile Mkr Beg	+ Disp_B	End Mile End	+ Disp_E	Proj cl Lnth	mile cl C&D	XSt ea SCS	mile cl FTM	Estimated Cost Construction	Estimated Cost Maintenance	Add FTE	SCU	LCU	CMS	LCS	CCTV	Loop	Ramp
		Summary					1985							0 000	0	0 000	$0 00	$0 00	0 0000		0	0	0	0	0	0
		Summary					1986							0 000	0	0 000	$0 00	$0 00	0 0000		0	0	0	0	0	0
		Summary					1987							0 076	0	0 000	$19,000 00	$0 00	0 0023		0	0	0	0	0	0
		Summary					1988							0 000	0	0 000	$0.00	$0 00	0 0000		0	0	0	0	0	0
		Summary					1989							0 833	0	0 000	$208,250 00	$0 00	0 0250		0	0	0	0	0	0
		Summary					1990							7 777	0	0 000	$1,944,250 00	$0 00	0 2333		0	0	0	0	0	0
		Summary					1991							0 000	0	0 000	$0 00	$0 00	0 0000		0	0	0	0	0	0
		Summary					1992							4 469	0	0 000	$1,117,250 00	$0 00	0 1341		0	0	0	0	0	0
		Summary					1993							3 086	0	0 000	$771,500 00	$0 00	0 0926		0	0	0	0	0	0
		Summary					1994							0 398	0	0 000	$99,500 00	$0 00	0 0119		0	0	0	0	0	0
		Summary					1995							0 000	0	0 000	$0 00	$0 00	0 0000		0	0	0	0	0	0
		Summary					1996							1 639	0	8 207	$4,513,250 00	$249,492 80	0 9519		1	33	8	33	21	451
		Summary					1997							0 000	0	0 000	$0 00	$0 00	0 0000		0	0	0	0	0	0
		Summary					1998							3 197	0	5 744	$3,671,250 00	$174,617 60	0 7278		1	23	6	23	14	316
		Summary					1999							12 108	0	7 688	$6,871,000 00	$233,715 20	1 2089		1	31	8	31	19	423
		Summary					2000							3 434	0	3 434	$2,575,500 00	$104,393 60	0 4808		0	14	3	14	9	189
		Summary					2001							15 924	0	0 000	$11,981,000 00	$640,000 00	0 4777		0	0	0	0	0	0
		Summary					2002							28 295	0	3 855	$8,501,250 00	$117,192 00	1 2129		0	15	4	15	10	212
		Summary					2003							25 761	0	7 864	$10,372,250 00	$239,065 60	1 6379		1	31	8	31	20	433
		Summary					2004							21 851	0	20 400	$15,662,750 00	$620,160 00	2 8995		2	82	20	82	51	1122
		Summary					2005							6 373	0	39 082	$21,134,250 00	$1,188,092 80	4 4902		4	156	39	156	98	2150
		Summary					2006							25 478	0	15 636	$14,187,500 00	$475,334 40	2 4843		2	63	16	63	39	860
		Summary					2007							6 524	0	9 511	$6,386,500 00	$289,134 40	1 2419		1	38	10	38	24	523
		Summary					2008							18 871	0	37 995	$23,715,250 00	$1,155,048 00	4 7456		4	152	38	152	95	2090
		Summary					2009							17 091	0	22 241	$15,393,250 00	$676 128 40	2 9592		2	89	22	89	56	1223
		Summary					2010							10 595	0	21 642	$13,469,750 00	$657,916 80	2 6985		2	87	22	87	54	1190
		Summary					2011							31 262	0	7 462	$11,546,500 00	$226,844 80	1 7587		1	30	7	30	19	410
		Summary					2012							7 859	0	13 592	$8,760,750 00	$413,196 80	1 7309		1	54	14	54	34	748
		Summary					2013							6 025	0	6 025	$4,518,750 00	$183,160 00	0 8435		1	24	6	24	15	331
		Summary					2014							8 152	0	25 952	$14,514,000 00	$788,940 80	3 0393		3	104	26	104	65	1427
		Summary					2015							6 164	0	10 164	$6,623,000 00	$308,985 60	1 3030		1	41	10	41	25	559

Note All items are tentative and subject to change

C&D cost data averaged from projects contracted through 11/96
Cost data from TxDOT Traffic Operations Division letter to Districts ., dated October 28, 1981

Term C&D = Conduit and Detection System
SCS = Signal Coordination System
FTM = Freeway Traffic Management System
XSt = Number of Cross Streets
FTE = Full Time Equivalent

SCU = System Control Unit @ (SCS XSt x 0 5)+(FTM mile x 0.1)
LCU = Local Control Unit @ (FTM mile x 4 0)
DMS = Dynamic Message Sign @ (FTM mile x 1 0)
LCS = Lane Control Signal @ (FTM mile x 4 0)
CCTV = Closed Circuit Television @ (FTM mile x 2 5)
Loop = Detection Device @ (SCS XSt x 36)+(FTM mile x 55)

Construction Costs

C&D Cost = $250,000/mile - includes ductbank, ground box & loops
SCS Cost = $17,000/XSt - includes equipment, diagonistics
FTM Cost = $500,000/Mile - includes SCU, LCU, CMS, LCS, CCTV, ramp meter, & cabinets

Maintenance Costs

C&D Cost = $0/mile
SCS Cost = Construction Cost x 8.0%
FTM Cost = Construction Cost x 8 0%

Additional FTE

C&D FTE = 0 03/mile
SCS FTE = 0 02/XSt

Table VA-2_Schedule of FTM Projects

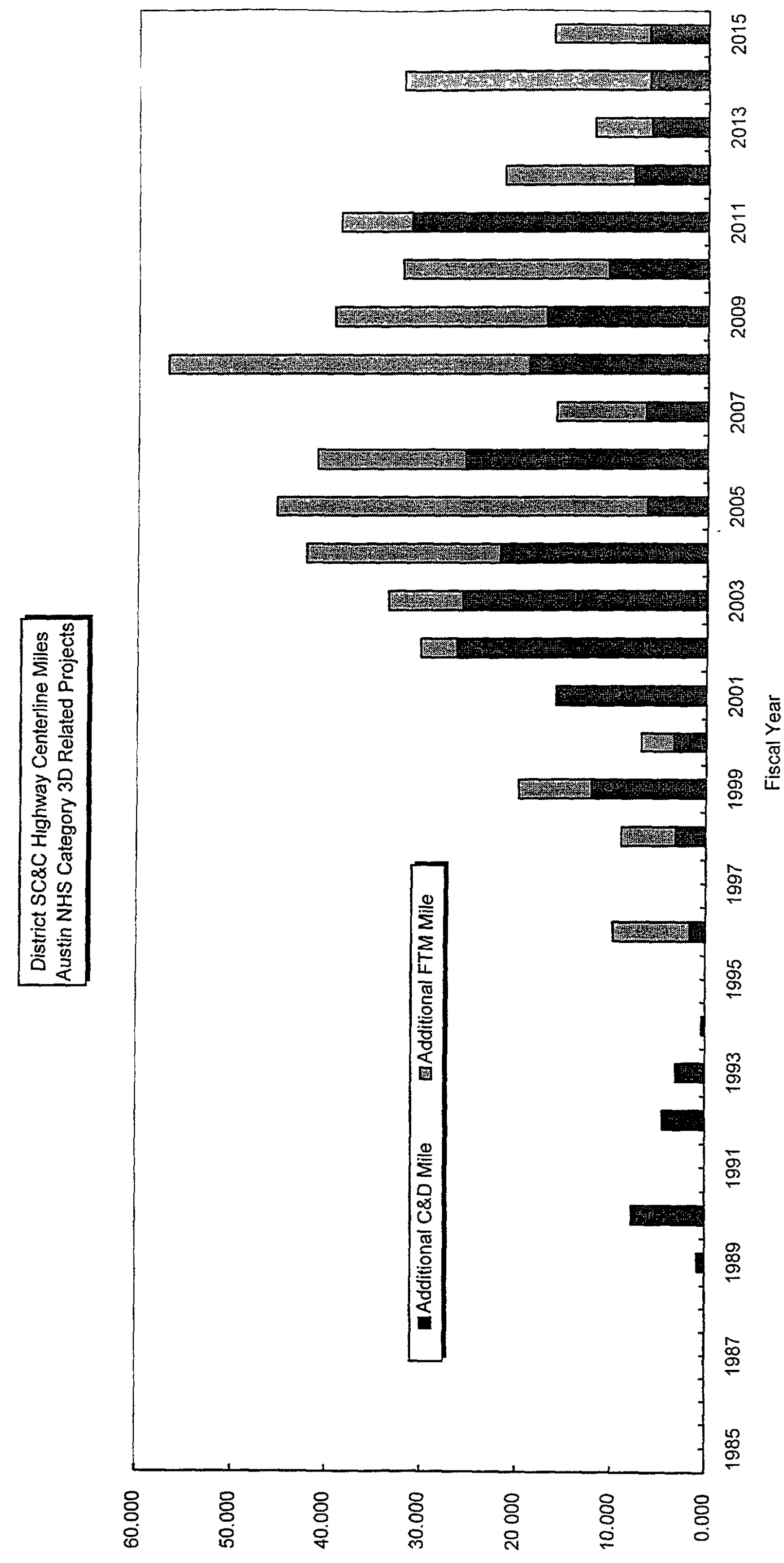

Figure VA-5_FTM Project Schedule Graph

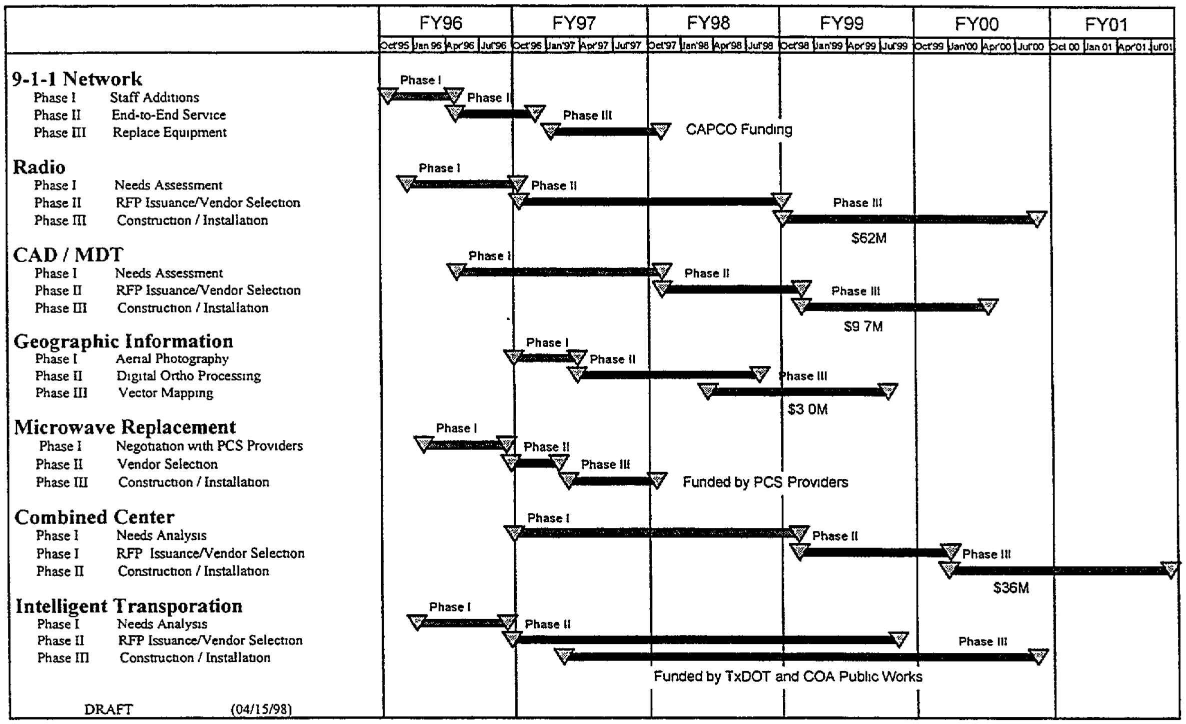

Figure VA-6_9-1-1 RDMT Timelines

Design Review

TxDOT has extensive experience with system components and communication subsystems described in this document for over twenty years. The system has proven its ability to manage traffic in other areas of the State such as Houston, Ft. Worth, and San Antonio.

It is envisioned that eventually projects would be reviewed by a multi-agency team. This team could represent the existing local traffic management team (TMT) or a working group of the Austin ITS Steering Committee developed with the *Austin Area-wide IVHS Plan.*

PROCUREMENT METHODS

TxDOT has traditionally utilized competitive procurement methods to construct highway improvements. The Engineer/Contractor method is usually used. Traffic management projects are typically procured as any other highway improvement. However, the maintenance of the system may utilize other competitive procurement methods. Uniform practices and procedures for procurement methods available to TxDOT are described in the *Manual of Procedures* maintained by the TxDOT General Services Division.

TxDOT procurement procedures will provide other alternate procurement methods when justified. This may need to be the case when experimental equipment or other entities are involved. For instance, the City of Austin is a significant stakeholder in the 9-1-1 RDMT combined center initiative. It is reasonable for the City of Austin to assume a lead role in the procurement of materials and services for this initiative.

Engineer/Contractor

This is the typical procurement method utilized by TxDOT for highway improvements, including traffic management systems. An engineer, either on staff or by consultant, prepares plans, specifications, and estimate (PS&E). The PS&E is reviewed and then advertised for bid. Usually a contract is awarded to the contractor submitting the lowest bid.

The schedule for review, advertising, and bidding follows established TxDOT procedure. The TxDOT *Design Division Operations and Procedures Manual* and the *PS&E Preparation Manual* contains additional detail on the PS&E process.

Funding is generally secured through one or a combination of TxDOT categories of funding. These categories are described in the Statewide Transportation Improvement Plan (STIP). The TxDOT categories include Federal, State, and local funding sources.

CONSTRUCTION MANAGEMENT PROCEDURES

The Austin District is divided into several areas, generally by county. There is an Area Engineer responsible for construction and maintenance activities in each area. Urban areas may have more than one Area Engineer depending on the location. Some design activities may also be completed by the Area Engineer’s office.

The Area Engineer’s office is familiar with managing large and complex construction projects. The Area Engineer’s office can best coordinate construction with other projects in the immediate area of a traffic management project.

The design of a traffic management system project is usually managed out of the District headquarters. However, construction and some maintenance activities are managed from the Area Engineer’s office. The headquarters design office may have limited involvement in the construction including submittal review and testing.

As in procurement, TxDOT has established construction management procedures for highway improvement projects. Either a formal or informal partnering process may be used in the management of construction activities. The partnering process identifies the division of responsibilities and conflict mitigation.

The *Area Engineers' and Inspectors' Contract Administration Handbook* along with *Standard Specifications for Construction of Highways, Streets and Bridges,* Standard Specification Items 1 through 9, further define construction management procedures including division of responsibilities, scheduling and mileposts, conflict mitigation, and coordination with other projects.

Although design and construction responsibilities reside in different TxDOT offices, the Austin District Transportation Operations has a history of close cooperation and active involvement with the construction office. It is also important to realize that projects with significant involvement with other agencies may mean that the other agency's construction procedures will be used. This may be case for the 9-l-l RDMT combined center initiative. In these cases, TxDOT has traditionally utilized contract agreements which insure the involvement and consideration of TxDOT's interests. The TxDOT Austin District Transportation Operations office has enjoyed a close partnering relationship with other agencies in the past.

SYSTEM START-UP PLAN

TxDOT has developed a special specification for statewide use on projects governing testing, training, documentation, and warranty. Additional special specifications, as well as, the general notes for the project can be used to further define these requirements.

Testing, whether hardware or software, generally includes a design approval test, demonstration test, stand alone test, and system integration test. The specifications describe each of these tests including consequences of failure and partial acceptance, if any.

Transition

A majority of the software used in the Austin District Freeway Traffic Management System has been developed by TxDOT to integrate the management of devices. However, some devices are controlled by proprietary software until such time that they can be integrated into the TxDOT software system. In addition, vendor proprietary software is envisioned to remain an integral part of the overall system as a functioning back up. Should TxDOT's integrated software fail the vendor's software will be utilized to manage the system.

Media and Public Support

Each TxDOT District has a full time equivalent (FTE) assigned as a public information officer (PIO). The Austin District has already begun involving the PIO in planning access to traffic information by the media. In addition, daily coordination with the PIO is envisioned to update highway advisory radio reports.

OPERATIONS and MAINTENANCE PLAN

This document is mainly concerned with describing the technical aspects of the Austin District Freeway Traffic Management System. Vital to the success of this technical system are standard operations and maintenance procedures. These procedures identify how the system will be operated and maintained from day to day. The *Traffic Management Center Advanced Traffic Management System Standard Operations Concept* contains many of the concepts used to form the day to day operations procedures. An important role in supporting the operations of this system is the freeway *courtesy* patrol. *The Austin District Freeway Courtesy Patrol Standard Operating Procedures* describes the operations of this important freeway traffic management function. In addition to operations, procedures are also needed to determine how the operations will be evaluated and maintained.

Evaluation

Evaluation measures are important, but often, difficult to achieve. Some baseline data before the system is implemented is desired. However, this before data is often difficult to obtain. Surveillance technology needed to collect the before data is often installed along with the other components of the freeway traffic management system. Computer equipment, needed to efficiently process the data, and the communication system components, to transport the data, are often the last work completed on projects. However, once the initial system computer and communications equipment have been installed it may be possible to phase the work on the next project so as to collect some surveillance data prior to the rest of the freeway traffic management system becoming operational.

Projects in the Austin District include instructions to the Contractor explaining the intention to collect data for the purposes of evaluation. The Contractor is asked to phase work accordingly. The initial focus of the evaluation will be the accuracy of detectors. Detector data is the foundation of the system in the Austin District. Almost all other system functions depend on accurate detector data. Detector data is also the primary means of evaluating services supported by the system.

Evaluator

It is desirable to have a third party evaluate the system performance and user satisfaction. This may not be possible in all cases. TxDOT, whether Division or District, must also continuously evaluate the systems it is responsible for operating.

Method of Evaluation

The *Austin Area-wide IVHS Plan* discusses evaluation techniques for each of the ITS strategies identified in the plan. These techniques along with others developed by an evaluation team should be employed. It is desirable to have a comprehensive independent evaluation at least every 5 years.

Cost of Evaluation

The cost of the evaluation will depend on the complexity of the system and user services evaluated. The Austin and El Paso Districts have very similar systems developed by the Traffic Operations Division. It may be possible to pool resources and coordinate an evaluation satisfying all three stakeholders involved.

Maintenance Plan

TxDOT is ultimately responsible for maintaining the freeway traffic management system. Maintenance and operations have traditionally been a line item of HB 1 discussed earlier under State legislature. Maintenance may be outsourced when beneficial. The development of ATMS software under the direction of the TxDOT Traffic Operations

Division has established ATMS software as the intellectual property of TxDOT. It is anticipated that ATMS software can be maintained under "work for hire" contracts in the future. TxDOT has a successful history of maintaining field hardware in the past. As in other areas, projects with significant involvement of other agencies may require a form of shared maintenance.

Maintenance Policies

The *Traffic Operations Manual*, *Signs and Markings Volume*, and *Traffic Signal Design and Application Volume* contain specific maintenance policies for equipment. These policies and procedures can be utilized for most devices.

Maintenance Management

TxDOT uses four different mainframe computersystems to track various information related to maintenance activity. The Maintenance Management Information System (MMIS) tracks specific maintenance work performed. The Salary and Labor Distribution system (SLD) tracks employee time. The Equipment Operations System (EOS) tracks equipment use. The Material Supply Management System (MSMS) tracks material use.

In addition, the Financial Information ManagementSystem (FIMS) tracks various financial information. The Minor Equipment System (MES) provides informationabout all aspects of minor equipment from requisition and purchase, through receipt, assignment to inventory, change in value, transfer, to retirement.

Spare Parts

Spare parts or units for most devices are currently obtained on construction projects at the rate of 10% of the contract amount. Additional spare equipment may be purchased following procurement guidelines. Spare equipment is entered into the MES.

Test Equipment

Test equipment is specified as needed on construction projects. Additional test equipment may be purchased by following procurement guidelines. This equipment also is entered into the MES.

Training

Training is generally specified along with the procurement of equipment and services. Training is provided as software and equipmentare brought into the system. Training can also be obtained through the TxDOT Human Resources Division as needed to supplement training accomplished through procurement.

INSTITUTIONAL ARRANGEMENTS

The *Austin Area-wide IVHS Plan* identified and established an institutional framework for planning and selection of Intelligent Transportation Systems (ITS) in the Austin area. This same institutional framework can be utilized beyond the planning and selection process to encompass maintenance and operations.

An example of this arrangement can be seen in the development of a combined regional emergency and transportation communication center (9-1-1 RDMT). A working group of the ITS Steering Committee functions within another institutional framework specific to 9-1-1 RDMT, The partners involved in 9-1-1 RDMT realize that institutional arrangements will need to be made to accommodate shared operations and maintenance. A 9-1-1 RDMT Finance Team Working Group has been established to formulate detailed goals and objectives for financing 9-1-1 RDMT operations and maintenance of initiatives. Separate working groups have been established for each 9-1-1 RDMT initiative to determine operation and maintenance needs.

Institution arrangements may also be necessary to expand the Freeway Courtesy Patrol in the future. This could be with vehicle vendors to supply patrolvehicles or other service and equipment vendors to sponsor courtesy patrol purchases.

PERSONNEL and BUDGET RESOURCES

Staffing Plan

The *Traffic Management Center Advanced Traffic Management System Operations Concept Document* identifies roles and responsibilities of staff needed to operate and maintain an advanced traffic management system (ATMS). The number of persons needed to fulfill the roles and responsibilities will vary depending on the size of the system, amount of maintenance contracted, and amount of resources that can be shared within a multi-agency center. A preliminary estimate of full time equivalent (FTE) persons needed is illustrated in Table VA-2 and Figure VA-9.

Shifts

Initially, the system may only be staffed by TxDOT during peak weekday periods. As the system expands, 24 hour staffing is desirable. TxDOT shifts may be eliminated depending on the ability to share resources with other agencies and the amount of automated tasks in the system.

Currently, the Freeway Courtesy Patrol operates exclusively along IH 35 during peak periods (6 a.m. - 9 a.m. and 4 p.m. - 6 p.m.) in two shifts. In between these times, two vehicles attempt additional patrols along US 183, US 290/ SH 71, LP 1, and LP 360. Additional patrols are needed to adequately operate on these facilities.

Contract Agreements

The use of contract operations staff is not currently anticipated. However, contract maintenance staff is under consideration. Contract staff may also be an option to expand the courtesy patrol.

Training

New staff utilizing TxDOT software and hardware may be trained on the job. Other avenues for training previously mentioned included training associated with equipment procurement and through the TxDOT Human Resources Division.

Budgetary Resources

TxDOT's budgetary resources are dependent on allocations from federal funds, a dedicated state motor fuel tax, and legislated general revenue. Federal funds are generally allocated on a formula basis approved by Congress. A bill authorizes these funds typically on a six year basis. This bill specifies funds in specific areas. Each area has specific requirements concerning eligibility and amount of matching participation. Each State submits a *Statewide Transportation Improvement Program* (STIP) indicating all projects including Federal assistance. This document is revised quarterly.

The Texas Legislature appropriates money for use by TxDOT arranged by strategies. The Texas Transportation Commission organizes all construction sources of funding into categories. The *Unified Transportation Program* (UTP) identifies the construction categories of funding approved by the Texas Transportation Commission. This document is updated each year.

Generally, budgetary resources may include design, construction, maintenance, and operations. Except for Interstate Highways, most federal assistance on projects is for 80% of the estimated construction cost. Federal assistance for maintenance and operations is currently limited and expenditures are currently 100% State funded.

Maintenance and operations budgetary allocations to district areas of the State are determined by TxDOT. Allocations are made on a fiscal year basis.

Annual Expenses

Annual maintenance and operations expenses are estimated at 8% of construction costs. As the system is installed and operated, these costs can be more accurately quantified Graphs illustrating the data contained in Table VA-2 are shown in Figures VA-7, VA-8, and VA-9. The information illustrated is only an estimate of what is needed to accomplish a system build out by 2015. Significant additional funding and resources will be needed to achieve this goal.

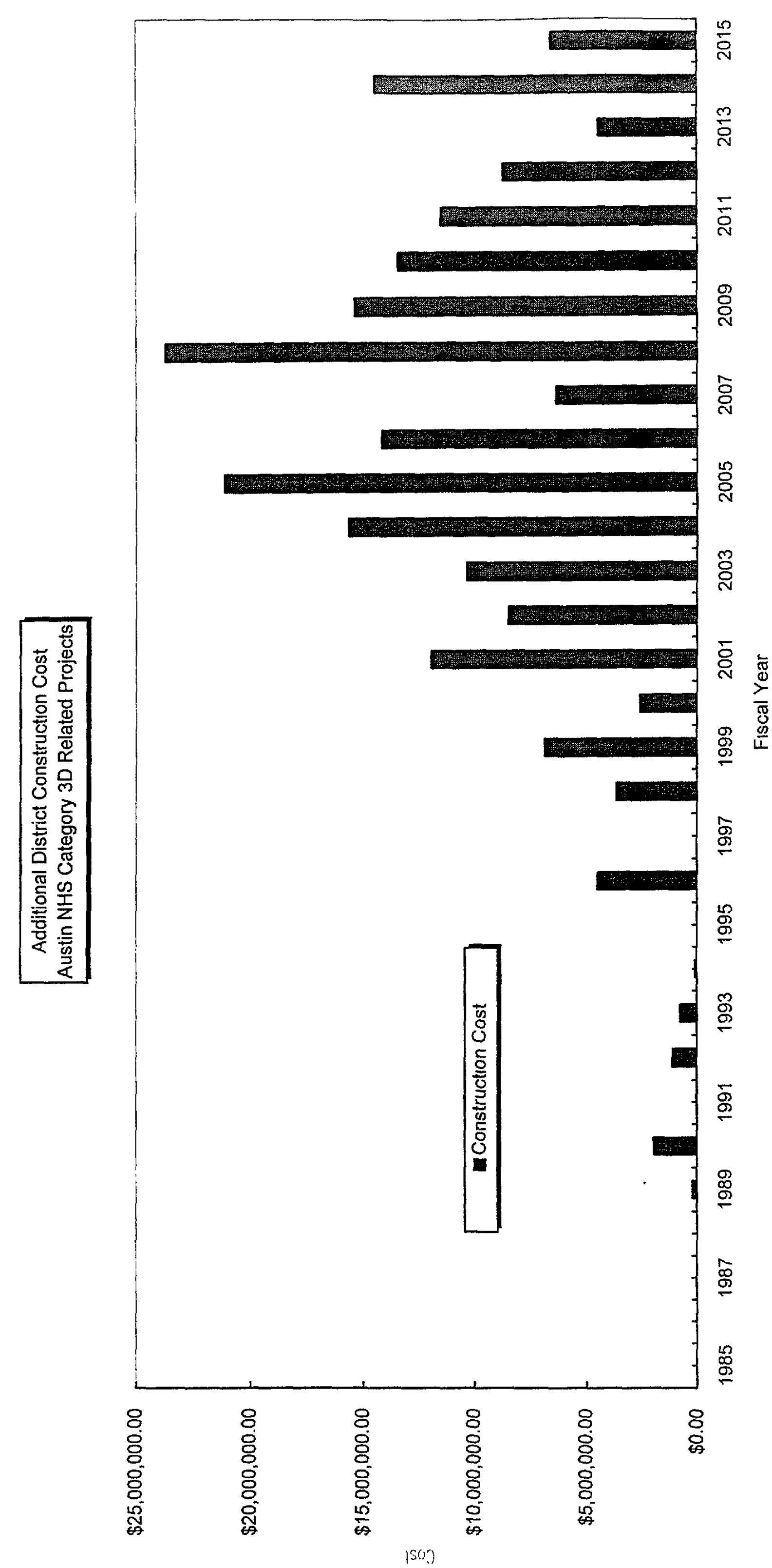

Figure VA-7_Estimated FTM Construction Cost

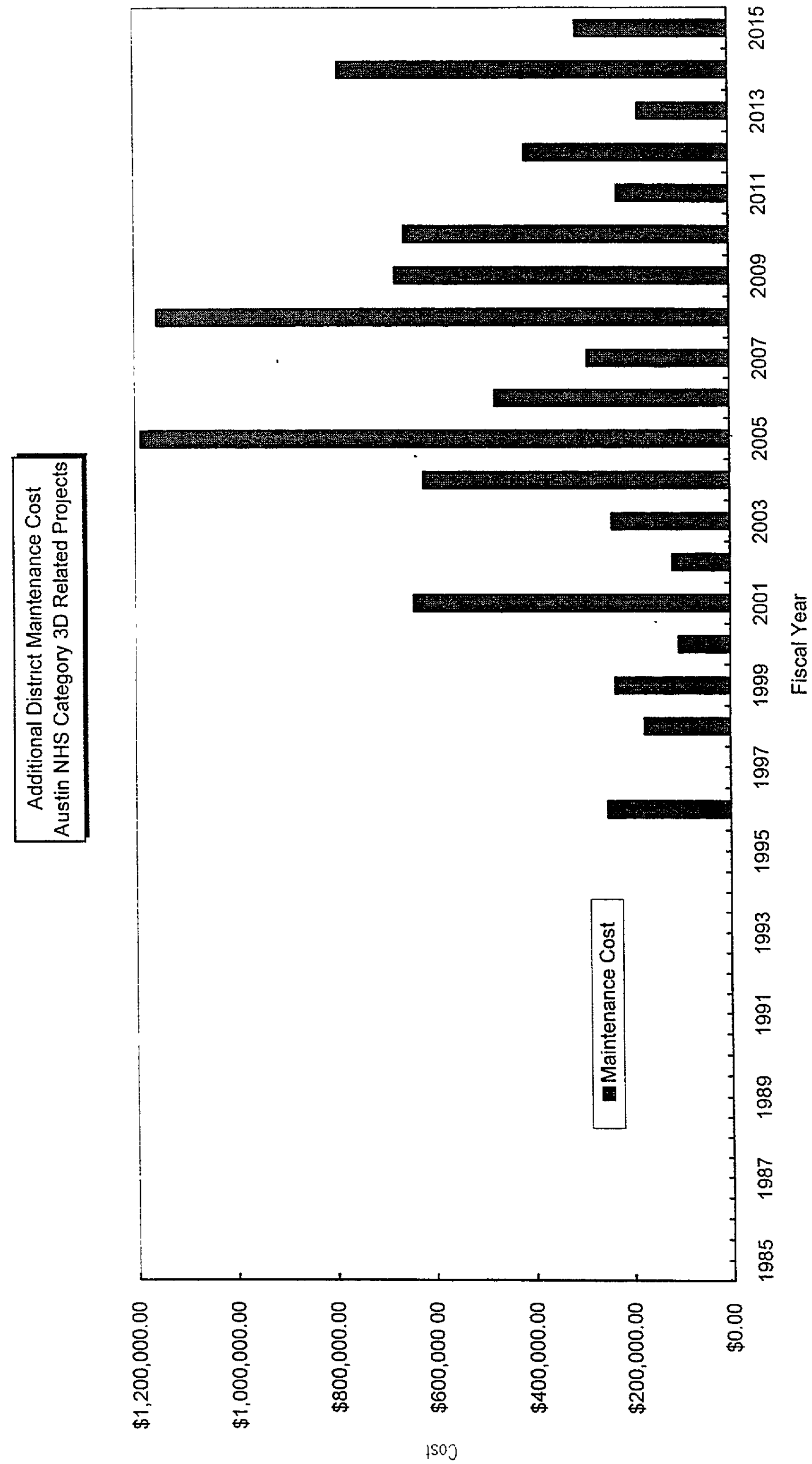

Figure VA-8_Estimated FTM Maintenance Cost

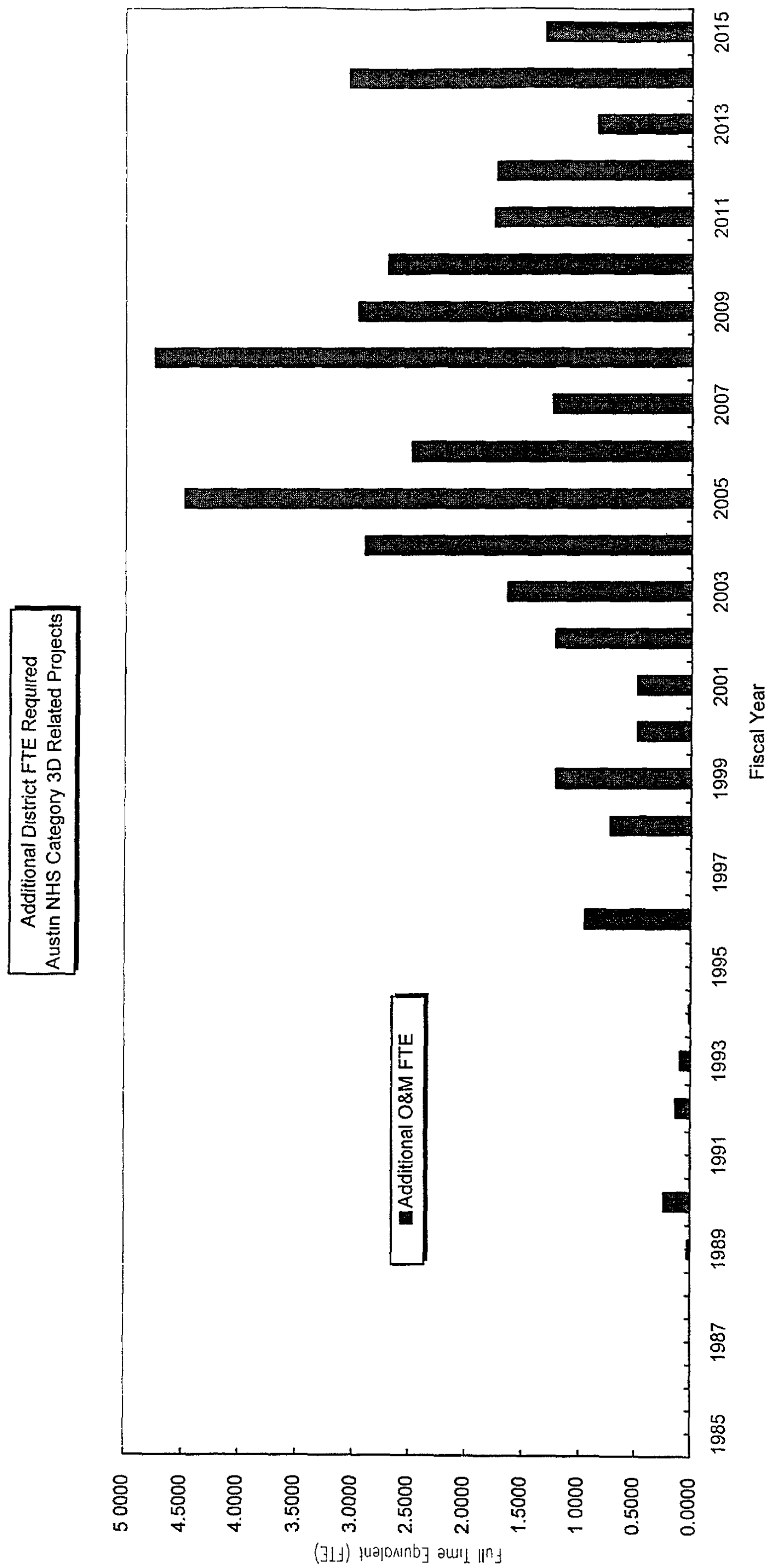

Figure VA-9_Estimated FTM FTEs

IMPLEMENTATION PLAN

for the

TEXAS DEPARTMENT OF TRANSPORTATION

AUSTIN DISTRICT

FREEWAY TRAFFIC MANAGEMENT SYSTEM

Recommended for implementation:

William C. Garbade, P.E. District Engineer TxDOT Austin District	David T. Newbern, P.E. Director TxDOT Traffic Operations Division
Charles W. Heald, P.E. Executive Director TxDOT	C.D. Reagan Division Administrator FHWA Texas Division